A machine for working sheet metal parts, in particular a flanging machine, and a system for driving the machine

The present invention relates to a machine for working sheet metal parts and to a driving system for such a machine. More particularly, the invention refers to a flanging machine for connecting by flanging sheet metal panels, such as, for example, car body panels.

Figures 1A to 1C of the appended drawings schematically show the operation of flanging a pair of sheet metal panels 1 and 2, that is, an outer panel and an inner panel, respectively. The two panels 1, 2 are first arranged (Figure 1A) with respective flat edge portions 3 and 4 in contact with each other on a workpiece-carrying structure (not shown), generally formed by a bed suitably shaped in accordance with the piece to be worked. The flat edge portion 3 of the outer panel 1 has an edge 3a which is initially bent at a given angle (typically 90 degrees) with respect to the plane of the portions 3 and 4 (Figure 1A) and is intended to be further bent and pressed on the flat edge portion 4, thereby clamping the latter against the underlying portion 3. The flanging operation usually includes a first phase, known as "pre-flanging", in which the edge 3a is bent to a given angle (typically 45 degrees) with respect to the plane of the edge portions 3 and 4 by applying a first force F1 preferably perpendicular to the said plane (Figure 1B), and a subsequent phase, or "final flanging", in which the edge 3a is further bent until it contacts the flat edge portion 4 and is then pressed against the latter by applying a second force F2, also preferably perpendicular to the plane of the portions 3 and 4 (Figure 1C).

For the sake of simplicity, it will be assumed hereinafter that the two flat edge portions 3 and 4 of the panels to be flanged are arranged in a horizontal plane and therefore that the direction along which the flanging forces are applied is vertical. The terms "horizontal" and "vertical" are thus to be understood, in the description and the claims which follow, as parallel to the plane on which the edge portions of the panels to be flanged lie and as perpendicular to that plane.

The flanging operation described above is commonly performed with the use of a tool-carrying unit 10 of the same type as that schematically shown in Figure 2. The tool-carrying unit 10 is mounted on the flanging machine (not shown) so that it can be moved vertically to perform the pre-flanging and the final-flanging operations, as well as moved substantially horizontally towards or away from the working area in order, for example, to allow the workpiece to be loaded or unloaded.

The unit 10 carries a first, pre-flanging tool 11 having a working surface 11a inclined at the pre-flanging angle (typically 45 degrees) with respect to the vertical direction, and a second, final-flanging tool 12 having a working surface 12a inclined at 90 degrees with respect to the vertical direction.

A flanging machine according to the preamble of independent Claim 1 is known, for example, from European patent application EP 0 924 005. According to this known solution, the vertical movement of the tool-carrying unit is driven by a screw mechanism controlled by an electric motor, whereas the movement towards and away from the working area (in this case, a tilting movement) is driven by a leverage controlled

by a pneumatic cylinder.

The use of a screw mechanism for driving the vertical movement (working movement) of the flanging machine has first of all the disadvantage of a high cost, due both to the high precision required for the production of the screw and to the complexity of the electronic control system required to ensure the correct operation of the machine. Moreover, the precision of the machine, and hence the quality of the worked pieces, may tend to decrease with time as a result of the plays due to the wear of the screw mechanism.

It is therefore the object of the present invention to overcome the shortcomings of the prior art discussed above, by providing a machine for working sheet metal parts, in particular for performing flanging operations, which has a simple structure, a low cost and a precise and reliable operation with time.

This and other objects are achieved according to the invention by virtue of a machine having the characteristics defined in the characterizing portion of independent Claim 1. Further advantageous characteristics of the invention are defined in the dependent claims.

A further independent Claim 15 relates to a driving system for a machine for working sheet metal parts, particularly for carrying out flanging operations.

The advantages of a machine according to the invention with respect to the prior art can be summarized in the following points:

- simpler construction,

- more compact sizes,
- lower manufacturing and working costs,
- lower number of components,
- higher reliability,
- less frequent and easier servicing operations, and
- greater working force which can be exerted, and therefore greater length which can be worked.

Further characteristics and advantages of the invention will become apparent from the detailed description which follows, given purely by way of non-limiting example with reference to the appended drawings, in which:

Figure 1A is a side sectional view which shows a pair of sheet metal panels arranged to be connected to each other by a typical double-phase flanging operation;

Figure 1B is a side sectional view which shows the two panels of Figure 1A after the 45-degrees pre-flanging phase;

Figure 1C is a side sectional view which shows the two panels of Figure 1A at the end of the final-flanging phase;

Figure 2 is a side sectional view which shows a tool-carrying unit adapted to carry out the flanging operation illustrated in Figures 1B and 1C;

Figure 3 is a perspective view from above and from the rear side which shows a flanging machine according to the invention;

Figure 4 is a perspective view from above and from the front side which shows the flanging machine of Figure 3, without

tool-carrying unit;

Figure 5 is a front elevation view of the flanging machine of Figure 3;

Figure 6 is a side sectional view of the flanging machine of Figure 3;

Figure 7 is a perspective view from above which shows a stationary base of the flanging machine of Figure 3;

Figure 8 is a perspective view which shows a section of a crank mechanism of the flanging machine of Figure 3 designed to control the longitudinal horizontal movement of the machine towards and away from the workpiece;

Figure 9 is a perspective view from above which shows a main body and a movable unit of the flanging machine of Figure 3, in the assembled condition;

Figure 10 is an exploded perspective view which shows the main body and a shaft and cam assembly for controlling the vertical movement of the movable unit of the flanging machine of Figure 3;

Figure 11 is a plan view which shows the outline of the cam of the flanging machine of Figure 3;

Figures 12A to 12K are partial side views which illustrate schematically the work-cycle of a flanging machine according to the invention; and

Figures 13 to 17 show the angular positions of the cam of a

flanging machine according to the invention at respective characteristic points of the work-cycle illustrated in Figures 12A to 12K.

Referring first to Figures 1 to 10, a flanging machine according to the invention, generally indicated 20, comprises:

a stationary base 22, intended to be fixed to the floor or mounted on a proper support plane (not illustrated) arranged parallel to the plane in which the edge portions of the sheet metal panels to be connected by flanging lie;

a movable base 24, mounted on the stationary base 22 so as to be movable parallel to the latter towards or away from the working area (double arrow X), hereinafter indicated as longitudinal direction;

a main body 26 fixed to the movable base 24 and having substantially a portal-like structure;

a movable unit 28, mounted on the main body 26 so as to be movable vertically (double arrow Z), that is, perpendicularly to the plane of the two bases 22, 24; and

a tool-carrying unit 10 of the same type as that described above with reference to Figure 2, which is fixed onto the movable unit 28.

In order to guide the translational movement of the movable base 24 along the direction X, the base is provided with a pair of longitudinal rails 30 (one of which can be partially seen in the sectional view of Figure 6) arranged to slide on respective guide surfaces 32a provided by two pairs of slid-

ing blocks 32 mounted on the stationary base 22 (Figure 7), The translational movement of the movable base 24 is driven by an electric geared motor unit 34 through a crank mechanism 36 (Figure 8) which converts the rotational movement into rectilinear movement.

With reference to Figures 7 and 8, the crank mechanism 36 comprises a vertical input shaft 38 connected at its top to the geared motor unit 34 so as to rotated by the latter. The shaft 38 is rotatably mounted by means of a bush 46 on a support body 40, which is fixed by screws 44 to the movable base 24 in a flange-like portion 42 thereof. The shaft 38 forms at its bottom a cylindrical extension 48 acting as a crank, which is placed eccentrically with respect to the axis of rotation of the shaft and on which a roller 50 is rotatably mounted. The roller 50, together with the associated extension 48, extends downwards into a through opening 52 provided in the movable base 24 (Figure 9) and is guided between a pair of vertical surfaces 54a which are oriented perpendicularly to the longitudinal direction X and are provided by respective guide members 54 secured to the stationary base 22.

In this way, when the geared motor unit 34 drives the rotation of the shaft 38, the roller 50 rolls along the guide surfaces 54a of the stationary base, while as a reaction the movable base 24, which is fast for translation with the shaft 38, moves longitudinally with respect to the stationary base 22 along the longitudinal guides 30, 32. The direction of the longitudinal movement of the movable base 24 is evidently set by suitably controlling the direction of rotation of the shaft 38.

In order to guide the translational movement of the movable

unit 28 along the direction Z, the unit is provided with a pair of vertical rails 56 (Figure 9) arranged so as to slide on respective guide surfaces provided by two pairs of sliding blocks 58 (which can be partially seen in the sectional view of Figure 6) mounted on the main body 26, in a similar manner as that described above in connection with the movable base 24.

The vertical translational movement of the movable unit 28 is driven by an electric geared motor unit 60 configured to rotate a driving shaft 62. The geared motor unit 60 is fastened to the movable unit 28 by means of screws 64 on the opposite side with respect to the working area. The shaft 62, which extends longitudinally, is supported for rotation in a support body 66 fitted in a through hole 68 of the movable unit 28.

The shaft 62 forms an end portion 70 (Figure 6) which has an outer eccentric-shaped surface and projects from the support body 66 towards the working area. Onto the eccentric portion 70 is secured an annular member 72 the outline of which extends parallel to that of the outer eccentric surface of the portion 70. Alternatively, there may be provided a cylindrical end portion 70 coaxial with the shaft 62 and an annular eccentric-shaped member 72.

A cam 76 is also fastened by means of screws 74 to the end portion 70 of the shaft 62 and has an outer surface 76a with an outline suitably shaped so as to control the vertical movement of the movable unit 28 according to a predetermined law, as will be described in detail further on. The cam 76 rests with its outer surface 76a on the outer cylindrical surface of a lower roller 78 rotatably mounted about a sta-

tionary shaft 80 of longitudinal axis, which is supported by a support member 82 attached to the movable base 24 (Figures 4 and 6).

An upper roller 86 (Figures 5 and 6) is rotatably mounted in a support portion 84 attached to a workpiece-carrying structure 88 (schematically illustrated in Figures 12A to 12K), the outer cylindrical surface of the roller co-operating with the outer surface 76a of the cam 76 during the pre-flanging phase, as will be explained in detail in the following part of the description.

According to a preferred embodiment of the invention, the flanging machine 20 is configured to perform a flanging operation of the type of that described in the introductory part of the description, that is, an operation consisting of a first, pre-flanging phase and a second, final-flanging phase. With reference to Figures 12A to 12K the work-cycle performed by the machine 20 will be described now.

The flanging machine is arranged first in a "loading/unloading" position (Figure 12A), in which the movable unit 28 is longitudinally spaced from the workpiece-carrying structure 88 so as to allow the loading of the workpieces to be flanged (for example, the panels 1 and 2 shown in Figures 1A to 1C).

Next (Figure 12B), the movable unit 28 is longitudinally moved towards the workpiece-carrying structure 88 (as indicated by arrow B_X) until the pre-flanging tool 11 is brought into contact with, or at least close to, the upper, 90-degree-bent edge 3a of the panel 1. The position so reached by the machine is indicated as "pre-flanging start" position.

At this time (Figure 12C), the pre-flanging phase is performed by vertically moving the movable unit 28 downwards (arrow C_Z) until the edge 3a of the panel 1 is bent up to 45 degrees. The position so reached by the machine is indicated as "pre-flanging end" position.

Figure 12D shows the machine in a "detachment after pre-flanging" position, reached by vertically moving the movable unit 28 upwards (arrow D_Z) so as to move the pre-flanging tool 11 away from the edge 3a of the panel 1.

The movable unit 28 is then moved away from the workpiece-carrying structure 88 by a longitudinal movement (arrow E_X) and reaches again the "loading/unloading" position shown in Figure 12E.

Figure 12F shows the flanging machine in a "preparation for final flanging" position, reached by vertically moving the movable unit 28 upwards (arrow F_Z) until the working surface 12a of the final-flanging tool 12 is brought to a higher level than the upper end of the edge 3a of the panel 1.

Figure 12G shows then the machine in a "final-flanging start" position, reached by longitudinally moving the movable unit 28 towards the workpiece-carrying base (arrow G_X) until the working surface 12a of the final-flanging tool 12 is brought above the edge 3a of the panel 1.

At this time (Figure 12H), the final flanging is performed wherein the movable unit 28 is vertically moved downwards (arrow H_Z) until the edge 3a of the panel 1 is further bent by 45 degrees and is finally pressed against the underlying edge 4 of the other panel 2. At the end of this phase, the

machine is in a position indicated as "final-flanging end" position.

Figure 12J shows the machine in a "detachment after final flanging" position, achieved by vertically moving the movable unit 28 upwards (arrow J_Z), so as to move the final-flanging tool 12 away from edge 3a.

Finally (Figure 12K), the movable unit 28 is again moved away from the workpiece-carrying structure 88 by a longitudinal movement (arrow K_X), thereby getting back in the "loading/unloading" position.

This work-cycle is performed by imparting a predetermined sequence of commands to the geared motor units 34 and 60 which control the longitudinal and vertical movements, respectively, of the movable unit 28. The vertical movements of the unit 28 are also determined by the shape of the outline 76a of the cam 76.

The shape of the outline 76a of the cam 76 according to a preferred embodiment of the invention and the sequence of commands imparted by the geared motor unit 60 to the cam in order to perform the work-cycle described above will be explained now in detail, with reference to Figure 11 and Figures 13 to 17.

The outline 76a of the cam 76 is shown in Figure 11, where the centre of rotation of the cam is indicated O. On the other hand, Figures 13 to 17 illustrate the angular positions reached by the cam 76 in the different working positions previously mentioned.

In a first phase, the two panels to be flanged are loaded onto the workpiece-carrying structure 88, while the machine is in the "loading/unloading" position illustrated in Figure 12A. In a second phase, the movable unit 28 is moved longitudinally to the "pre-flanging start" position illustrated in Figure 12B. During these first two phases the movable unit 28 is not moved vertically, but the cam 76 is held in the initial position shown in Figure 13, in which the cam contacts the lower roller 78 in a point P_{AB} of its outline.

In a third phase, the pre-flanging is performed, whereby the movable unit 28 is vertically moved downwards until it reaches the "pre-flanging end" position illustrated in Figure 12C. This third phase is comprised of the following three steps.

The cam 76, which rests on the lower roller 78 together with the whole movable unit 28 drivingly connected thereto, is first caused to rotate counter-clockwise in such a manner that its point of contact with the roller 78 moves from point P_{AB} specified above to a second point P_{C1}. The segment of cam outline 76a comprised between points P_{AB} and P_{C1} is shaped in such a manner that it causes the movable unit 28 to move downwards until the working surface 11a of the pre-flanging tool 11 is brought into contact with the 90-degree-bent edge 3a of the sheet metal outer panel 1.

The outline portion 76a of the cam 76 following point P_{C1} would correspond to a further downward movement of the movable unit 28, if this latter continued to rest with the cam 76 on the lower roller 78. As a matter of fact, by causing the cam 76 to rotate counter-clockwise again, the movable unit 28 remains "suspended" on the edge 3a of the panel 1

with its tool 11, while the cam 76 disengages from the lower roller 78 and starts to engage with the upper roller 86, drivingly connected to the workpiece-carrying structure 88, starting approximately from a point P_{C1}^* opposite point P_{C1} or from a following adjacent point. This second step provides for a rotation through nearly 60 degrees, until the cam 76 comes into contact with the upper roller 86 in a point P_{C2}. Since the outline segment comprised between points P_{C1}^* and P_{C2} is an arc of circumference, no vertical movements of the movable unit 28 take place during this second step.

As the cam 76 continues to be rotated, it engages with the upper roller 86 along the outline segment 76a comprised between point P_{C2} and a point P_{C3} and finally reaches the position shown in Figure 14. Since this outline segment provides for an increase in the radial distance from the centre of rotation O, the cam 76 is urged downwards dragging with it the movable unit 28 and the tool-carrying unit 10 mounted thereon. The pre-flanging tool 11 can thus perform the pre-flanging operation, by exerting on the edge 3a of the panel 1 a bending force which is the sum of the weight of the movable unit 28 and of the downward load brought about by the interaction of the cam 76 with the upper roller 86.

In a fourth phase, the movable unit 28 is moved vertically upwards until it returns into the "pre-flanging start" position. To this end, the cam 76 is caused to rotate clockwise until it returns into the initial position shown in Figure 13, in which it contacts the lower roller 78 in point P_{AB}.

In a fifth phase, the movable unit 28 is moved longitudinally until it reaches the "loading/unloading" position illustrated in Figure 12E, while the la cam 76 is held stationary in the

initial position of Figure 13.

In a sixth phase, the movable unit 28 is moved vertically upwards until it reaches the "preparation for final flanging" position illustrated in Figure 12F. To this end, the cam 76 is caused to rotate clockwise whereby the point of contact with the lower roller 78 moves along the outline segment comprised between point P_{AB} and a point P_F (which coincides with point P_{C3} previously identified), as shown in Figure 15.

In a seventh phase, the movable unit 28 is moved longitudinally towards the workpiece-carrying structure 88 until it reaches the "final-flanging start" position illustrated in Figure 12G, while the cam 76 is held stationary in the angular position shown in Figure 15.

In an eighth phase, the final flanging is performed by moving the movable unit 28 vertically downwards up to the "final-flanging end" position illustrated in Figure 12H. To this end, the cam 76 is caused to rotate clockwise until it reaches the angular position shown in Figure 16. As well as for the pre-flanging phase, the final-flanging phase also is comprised of three steps.

First the cam 76 is caused to rotate clockwise in such a manner that its point of contact with the lower roller 78 moves from point P_F specified above to a point P_{H1}. The outline segment 76a of the cam comprised between points P_F and P_{H1} is shaped in such a manner that it brings about a downward movement of the movable unit 28 until the working surface 12a of the final-flanging tool 12 is brought into contact with the 45-degree-bent edge 3a of the sheet metal outer panel 1.

As the cam 76 continues to be rotated clockwise, it disengages from the lower roller 78, while the movable unit 28 remains "suspended" on the bent edge 3a. At the same time, the eccentric annular member 72, which is fast for rotation with the cam 76, starts to engage with an abutment surface 90 provided by the workpiece-carrying structure 88, namely by the support portion 84 fixed to this structure (which can be seen in the side-sectional view of Figure 6).

In a similar way to what has been described with reference to the pre-flanging operation, as a result of the interaction between the outline of the eccentric annular member 72 and the abutment surface 90, the movable unit 28 and the tool-carrying unit 10 mounted thereon are urged downwards until they reach the "final-flanging end" position. During this third step, the final-flanging tool 12 exerts on the edge 3a of the panel 1 a bending force which is the sum of the weight of the movable unit 28 and the downward load produced by the interaction of the eccentric annular member 72 with the abutment surface 90.

By suitably dimensioning the annular eccentric member 72, the load which is obtained during the final flanging phase is advantageously far higher (for example, nearly four times higher) than that exerted during the pre-flanging phase. Moreover, since the bending force exerted by the tool 12 on the edge 3a is substantially aligned with the contact force between the annular eccentric member 72 and the abutment surface 90 (as is visible from the side sectional view of Figure 6), these forces do not produce a torque which could adversely affect the working precision.

In a nine phase, the movable unit 28 is moved vertically up-

wards until it gets back in the "final-flanging start" position. To this end, the cam 76 is caused to rotate counter-clockwise until it gets back in the angular position shown in Figure 16, in which it contacts the lower roller 78 in point P_F.

A tenth phase follows, in which the movable unit 28 is moved away longitudinally from the workpiece-carrying structure 88 until it reaches the "loading/unloading" position illustrated in Figure 12K, while the cam 76 is held stationary in the angular position of Figure 16.

In a last phase, the movable unit 28 is moved vertically downwards so as to get back in the cycle start position of Figure 12A. To this end, the cam 76 is caused to rotate counter-clockwise until its point of contact with the lower roller 78 is brought at point P_{AB} of its outline, as shown in Figure 18. At this time, with the movable unit 28 held in position, the worked piece is unloaded.

Naturally, the principle of the invention remaining unchanged, embodiments and manufacturing details may vary widely from those described and illustrated purely by way of non-limiting example.

In particular, although there is described and illustrated a preferred embodiment of a flanging machine arranged to perform a double-phase flanging operation (45-degree pre-flanging and 90-degree final-flanging), it is clear that the same machine can be easily modified in a suitable manner for performing any other type of flanging operation, for example with a different pre-flanging angle or without the pre-flanging phase, or again with a different final-flanging an-

gle.

Moreover, it is clear that a machine according to the invention can also be used to perform other types of working which provide for the application of a bending force in a given direction. By suitably modifying the outline of the cam, in fact, it is possible to make the tool-carrying unit to move according to a movement law suitable for the particular type of working to be performed.